User Manual

This document provides instructions on how to use the XTEAM modeling and analysis environment. This document does not provide general usage instructions for GME. For help with GME, see the GME documentation at:
http://www.isis.vanderbilt.edu/projects/gme/Documentation.html

1 Getting Started

This section describes how to install and setup XTEAM. You must use Microsoft Windows XP, Windows Vista, or Windows 7.

1.1 Install the Software Packages

Install GME Version 10.2.9

Download and run the install file from:
http://www.isis.vanderbilt.edu/projects/gme/. You will have to register with Escher. You may use all the default installation options.

Install Microsoft Visual Studio 2008

You must purchase Visual Studio if you do not already have it. Most universities make it available to students through MSDNAA.

Download XTEAM

Download and extract the source from:
http://softarch.usc.edu/~gedwards/download/xteam10.2.9.zip

Download and extract *adevs* Version 1.3.3

Download and extract the source from:
http://softarch.usc.edu/~gedwards/download/adevs-1.3.3.zip

Download and extract Newran Version 02

Download and extract the source from:
http://softarch.usc.edu/~gedwards/download/newran02.zip

1.2 Set up the XTEAM Environment

This section provides instructions for setting up the XTEAM environment in GME, creating a new project, running the simulation generator, and viewing the example and metamodel. The instructions below are written for the FastxADL paradigm and simulation generator. To use the instructions for any of the other paradigms or simulation generators, just substitute the paradigm name (e.g., PowerxADL) for FastxADL in the instructions below.

Important: Under Windows Vista and Windows 7, you must run GME and Visual Studio under Administrator Mode or disable Windows User Account Control (UAC).

Register the XTEAM Paradigm.

1. Open GME.
2. Choose `Tools`→`Register Paradigms`…
3. A dialog box titled `Select Paradigm` will appear. Click `Add from File`…
4. A dialog box titled `Open` will appear. Browse to the location where you saved `xteam\paradigms\FastxADL\FastxADL.xmp` and select that file. Click `Open`.
5. The XTEAM FastxADL paradigm is now registered. Repeat this process for any other paradigms you wish to use.

Create a New Project.

1. Choose `File`→`New Project`…
2. A dialog box titled `Select Paradigm` will appear. Select `FastxADL` from the list and click `Create New`…
3. A dialog box titled `New` will appear. Click `Next>`.
4. A dialog box titled `Open` will appear. Browse to the location where you want to store your project, give your project a file name, and click `Open`.
5. You now have an empty project open.

Open the Example Model.

1. Choose `File`→`Import XML`…
2. A dialog box titled `Open` will appear. Browse to the location where you saved `xteam\examples\`. Three additional folders containing models of example systems are in this folder: `Mobile`, `Rescue`, and `XML`. Each example system is modeled in two or more architectural styles. The model of each system for each style is contained in a subfolder. Choose one of the example models, and select the "`.xme`" file contained in the appropriate folder. For example, if you want to open the RescueApp system modeled with the Client/Server architectural style, select `Rescue\CS\RescueApp.xme`. Click `Open`.

3. A dialog box titled `Import to new project` will appear. Click `Next`.
4. Choose the location where you would like to save the project file. This is a binary version of the model (as opposed to XML) that GME uses when you have the model open. Click `Open`.
5. You may see a dialog box appear that says "This model was exported using paradigm FastxADL Version ID: {…} Do you want to upgrade to the current version? Current ID: {…}." Click `Yes`.
6. The model is now open.

Register the Simulation Generator.

1. When you have a `FastxADL` model open, choose `Tools→Register Components…`
2. A dialog box titled `Components` will appear. Click `Install New…`
3. A dialog box titled `Open` will appear. Browse to the location where you saved `xteam\interpreters\FastxADL2adevsBON2Component.dll` and select that file. Click `Open`.
4. The simulation generator is now registered. Repeat this process for any other simulation generators you wish to use.

Run the Simulation Generator.

1. When you are ready to generate a simulation of your architecture, double click the architecture model to open it.
2. Choose `Tools→FastxADL Simulation Generator` or `Tools→Run Interpreter→FastxADL Simulation Generator`.
3. The simulation generator will run and you will see a number of C++ source files appear in the directory where your model is saved.

Open the Metamodel (optional).

1. Choose `File→Import XML…`
2. A dialog box titled `Open` will appear. Browse to the location where you saved `xteam\paradigms\FastxADL\FastxADL.xme` and select that file. Click `Open`.
3. A dialog box titled `Import to new project` will appear. Click `Next`.
4. Choose the location where you would like to save the project file. This is a binary version of the model (as opposed to XML) that GME uses when you have the model open. Click `Open`.
5. You should see a dialog box that says "The XML file was successfully imported." Click `OK`.
6. The metamodel is now open. You may view any of the paradigm metamodels in this manner.

Compile the Simulation Generator (optional).

1. In Microsoft Visual Studio 2008 or later, open the `FastxADL2adevs.sln` solution file.
2. Open the file `SimGenInclude.h`. Make sure that the first line of this file contains an include directive for `xteam/interpreters/FastxADL2adevs/FastxADL2BonX.h`.
3. Choose `Build→Build Solution`.

2 Modeling Elements

This section describes the modeling elements used to create XTEAM models.

2.1 Structural Elements

Note: For more information about the XTEAM structural modeling elements, see the xADL Structures and Types documentation at:
http://www.isr.uci.edu/projects/xarchuci/ext-overview.html#types

Components represent the loci of computation. They either contain a sub-architecture (consisting of components and connectors) or they contain a behavioral model (defined in terms of processes). They are connected to other components and connectors through their contained interfaces. Create component types in an Elements folder, then instantiate those types in architecture models.

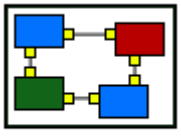
May Contain: Architecture, Interface, Resource, Process
Attributes:

- Description – a generic string that describes the component.

Connectors are the same as components in terms of the way they are modeled. However, connectors are generally used in a different way in an architecture model – components implement business logic, while connectors perform functions such as remote connection establishment, message routing and filtering, etc.

May Contain: Architecture, Interface, Resource, Process
Attributes:

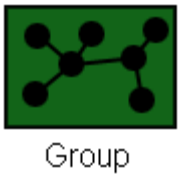
- Description – a generic string that describes the connector.



Architectures represent collections of components and connectors that have been instantiated in a specific topology. Architectures can be used to capture the substructure of components and connectors or the arrangement of top-level components and connectors in a software system.

May Contain: Component, Connector, Group, Interface
Attributes:

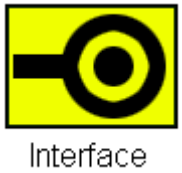
- Description – a generic string that describes the architecture.



Groups represent sets of components and connectors. The components and connectors within a group share a thread pool and a FIFO event queue. All components and connectors must belong to exactly one group, and that group must reside in the same architecture as the component or connector.

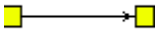
May Contain: Components, Connectors
Attributes:

- Description – a generic string that describes the group.
- Thread pool size – the number of threads available to perform tasks for elements in the group.

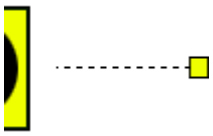


Interfaces represent the connection points between components and connectors. Interfaces are connected to other interfaces via links, which represent a logical connection between interfaces, and interface mappings, which denote the realization of a higher-level interface by the interface of a subcomponent. Interfaces are contained by components, connectors, and architectures, and appear as ports on those objects. Interfaces contain inputs and outputs that describe the type of information exchanged over the interface.
May Contain: Input, Output
Attributes:

- Description – a generic string that describes the interface.
- Direction – an enumerated type that may be set to none, in, out, or inout. An “in” interface is a provided interface, while an “out” interface is a required interface. An “inout” interface contains both provided and required parts.



A ***Link*** represents a logical connection between components or connectors over which information is exchanged. The link should be used between components or connectors that exist at the same level within the structural hierarchy. Links are directed, one-way connections – to make a bidirectional connection, create another link in the opposite direction.
May Contain: None
Attributes: None



An ***Interface Mapping*** represents the realization of an interface by the interface of a sub-component or sub-connector. The interface mapping should be used between components or connectors that are a different levels of the structural hierarchy (i.e., one is a sub-element of the other). Interface mappings are two-way, bi-directional connections.
May Contain: None
Attributes: None

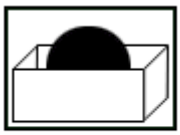
2.2 Data Elements

An ***Input*** represents data that is received through an interface. The data type is specified through a contained reference to a datum (called a ***PortType***).

May Contain: PortType
Attributes: None

An ***Output*** represents data that is sent through an interface. The data type is specified through a contained reference to a datum (called a ***PortType***).

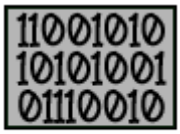
May Contain: PortType
Attributes: None



A ***Resource*** represents a data object that is local to a particular component or connector (*i.e.*, only that component or connector has access to it). Resources can be used to store inputs and outputs and maintain the state of a component or connector. The type of the resource data is specified through a contained reference to a datum (called a ***ResourceType***).

May Contain: ResourceType
Attributes:

- Initialization – a set of C++ statements that initialize the resource.



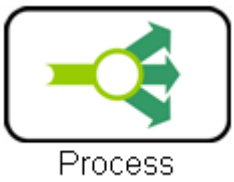
A ***Datum*** represents an object type that is used by components and connectors. Create a reference to a datum within an input, output, or resource to represent a type specification for those elements. Datum objects may be hierarchically contained to create complex types.

May Contain: Datum
Attributes:

- Description – a generic string that describes the datum.
- Size – the size of the datum. May be set to an equation involving a random value.
- Type – an enumerated type that specifies the type of the datum. May be set to one of several primitive types (integer, real, string, Boolean) or composite, which should be used when the datum contains other datum objects.

2.3 Behavioral Elements

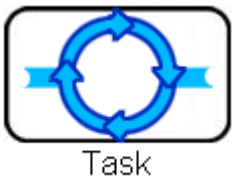
Note: For more information about the XTEAM behavioral modeling elements, please see the Finite State Processes (FSP) documentation at:
http://www.doc.ic.ac.uk/~jnm/LTSdocumention/FSP-notation.html



A ***Process*** represents a sequence of actions that is carried out by a component or connector. Processes are used to capture the behavior of primitive components (*i.e.*, components that do not have a modeled substructure). XTEAM processes are a form of enhanced finite state processes (FSP).

May Contain: Start, Task, Choice, Conditional, Event, ResourceUsage, ProcessTransition, Stop
Attributes: None

A ***Start*** represents the starting point for a process. A thread must be acquired from the thread pool before execution can begin.
May Contain: None
Attributes: None



A ***Task*** represents a job that is performed by a component or connector. Tasks are commonly used to manipulate the state of a component or connector or perform some computation. The amount of time required to complete the task is specified by the execution time attribute.

May Contain: None
Attributes:

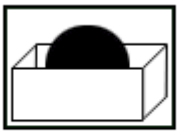
- Execution time – the time required for the task to complete.
- Instruction – a set of C++ statements that are performed when the task executes.

A ***Choice*** represents a branch in the control flow of a process. It is used to select from among multiple possible control paths based an *external* stimulus (input).
May Contain: None
Attributes: None

A ***Conditional*** represents a branch in the control flow of a process. It is used to select from among multiple possible control paths based the *internal* state of a component or connector.
May Contain: None
Attributes: None

Event

An ***Event*** represents the occurrence of an input or output. An event is a reference an input or output.
May Contain: None
Attributes: None



ResourceUsage

A ***ResourceUsage*** represents the accessing of the data contained in a resource. The access could be either a write (to store an input) or a read (to send an output). A resource usage is a reference to the resource that is being accessed.
May Contain: None
Attributes: None

ProcessTransition

A ***ProcessTransition*** represents the branching of control from the current process to a new process.
May Contain: None
Attributes: None

Stop

A ***Stop*** represents the termination of a control flow path. A thread that reaches a stop element is returned to the thread pool.
May Contain: None
Attributes: None

3 Performing Analysis

3.1Compiling a Simulation

XTEAM simulations can be compiled using any C++ compiler. In order to build an executable XTEAM simulation, you must compile the source files generated by an XTEAM interpreter and link in the adevs and Newran source. The simplest way to do this is to build adevs and Newran as static libraries (*.lib files in Windows and *.a in Linux).

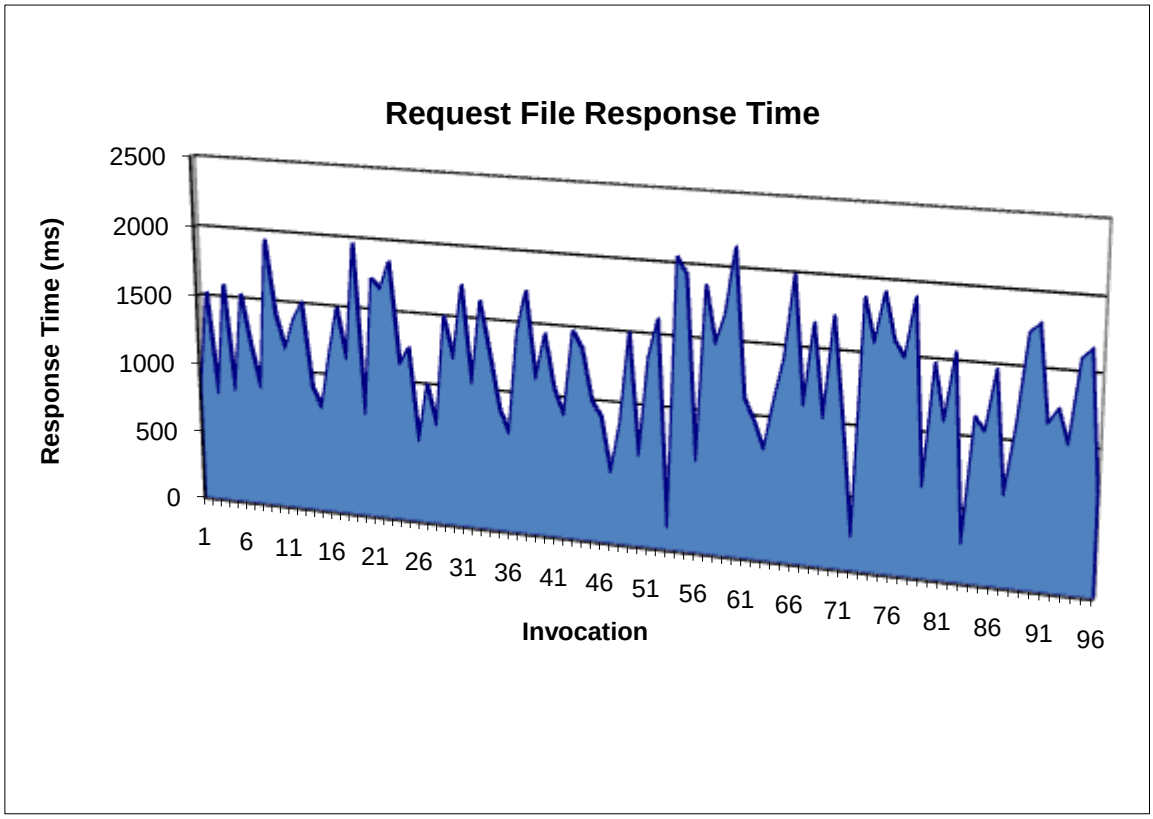
Since GME runs under Windows and is integrated with Microsoft Visual Studio, the instructions provided here are for MS Visual Studio.

1. Create a new C++ project in Visual Studio. Choose `Empty Project` in the `New Project` wizard.
2. Add all the source files generated by the XTEAM interpreter to your project.
3. Add all the source files in the folder `xteam/src/simulator` to your project.
4. Change the following project properties by selecting `Project→Properties`.
    a. Under `Configuration Properties→C/C++→General`, add the following folders to the `Additional Include Directories` property:
        i. `xteam/src/simulator/`
        ii. `newran02/`
        iii. `adevs-1.3.3/include/`
    b. Under `Configuration Properties→Linker→General`, add the following folders to the `Additional Library Directories` property:
        i. `adevs-1.3.3/bin`
        ii. `newran02`
    c. Under `Configuration Properties→Linker→Input`, add the following files to the `Additional Dependencies` property:
        i. `adevs.lib`
        ii. `newran.lib`
    d. Under `Configuration Properties→C/C++→Code Generation` change the `Runtime Library` property to `Multi-threaded (/MT).`
5. You can now build the executable simulation by selecting `Build→Build Solution`.
6. Run the simulation by selecting `Debug→Start Debugging`.

3.2 Using the Latency Extension (FastxADL)

When you generate, compile, and run the latency simulation, a file will be produced for each “out” interface with the name “InterfaceName_InterfaceID_Latency_Log.csv”. You can open this file in MS Excel. Each row in the spreadsheet corresponds to an invocation

of the interface. The first column is the time of the request, the second column is the time of the response, and the third column is the round-trip time. Plotting these values yields a graph like the one below:



3.3 Using the Energy Consumption Extension (PowerxADL)

Note: See the paper "An Energy Consumption Framework for Distributed Java-Based Software Systems" by Seo et al. for more information about how the energy consumption estimation works: http://www-scf.usc.edu/~cseo/publication/usccse2006-604.pdf.

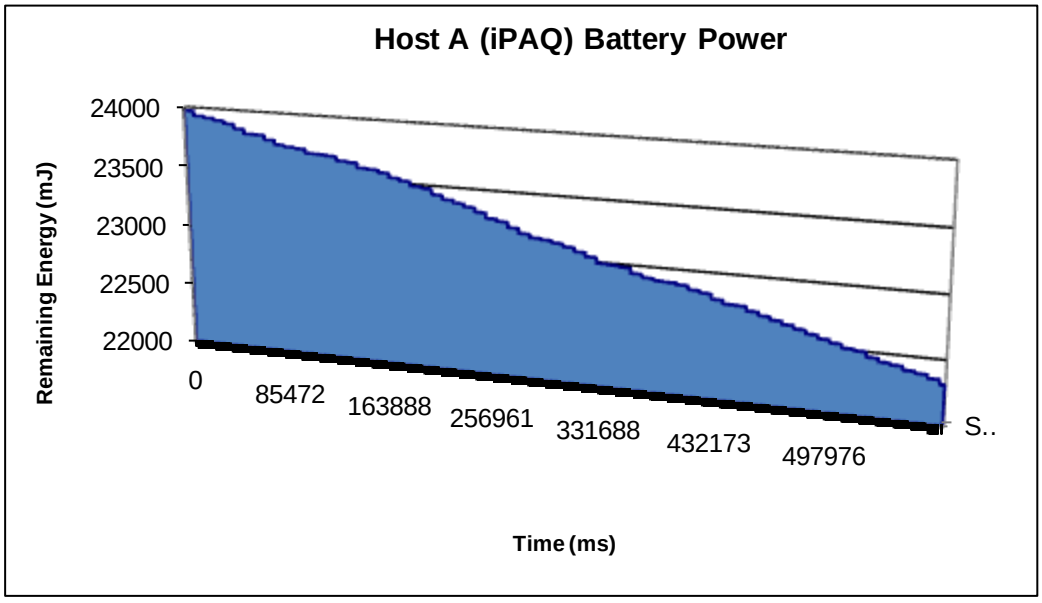
Once you have imported your model into the PowerxADL paradigm, if you have not already done so, create a `Host` element in your top-level architecture corresponding to each host in your system. Choose the set of components that are deployed to each host by clicking on "Set Mode" on the toolbar on the left and then right click on a `Host`. All the elements in the model will become grayed-out. Now, left click on the components and connectors you want to deploy to the `Host`. When you are done choosing the deployment, right click again, and repeat the process for the remaining `Hosts`.

For each `Host`, fill in the following attributes according to measured or estimated values, as given in the paper referenced above:

`Transmit energy cost per byte`
`Transmit constant energy overhead`
`Receive energy cost per byte`
`Receive constant energy overhead`

For each `Interface`, fill in the `Invocation energy cost` attribute with energy cost in Joules of invoking the interface. You may use a constant value, a stochastic value, or some other equation that may include the size and/or value of an input or resource as a parameter.

When you generate, compile, and run the simulation, you will see a new file created for each component and connector named "ElementName_ElementID_Energy_Log.csv". You can open this file in MS Excel. The first column is the time in milliseconds. The second column is the energy cost incurred by the component at that time. You can determine the total energy used by a component up to a particular time by summing the values in the second column. Subtracting these values from a known battery capacity and plotting them as a function of time yields a graph like the one below:



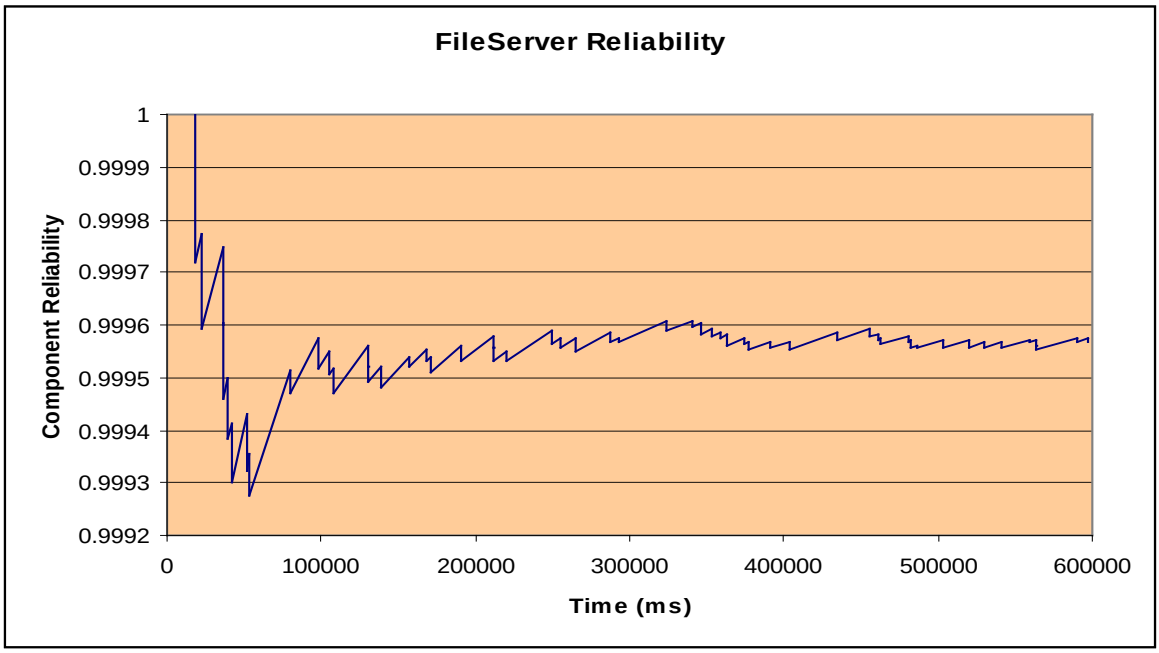
3.4Using the Reliability Extension (SafexADL)

Note: See the paper "Estimating Software Component Reliability by Leveraging Architectural Models" by Roshandel et al. for more information about how the reliability estimation works: http://doi.acm.org/10.1145/1134285.1134432.

Once you have imported your model into the SafexADL paradigm, create a `Failure` element for each type of failure that can occur during each `Task`. Fill in the `Failure probability` attribute with a probability between 0 and 1 that the failure occurs

during any single execution of the task. Fill in the `Recovery time` attribute with the time in milliseconds required to recover from the failure. Create a `Fail` connection from the task to the failure, and a `Recover` connection from the failure to the next process executed on recovery.

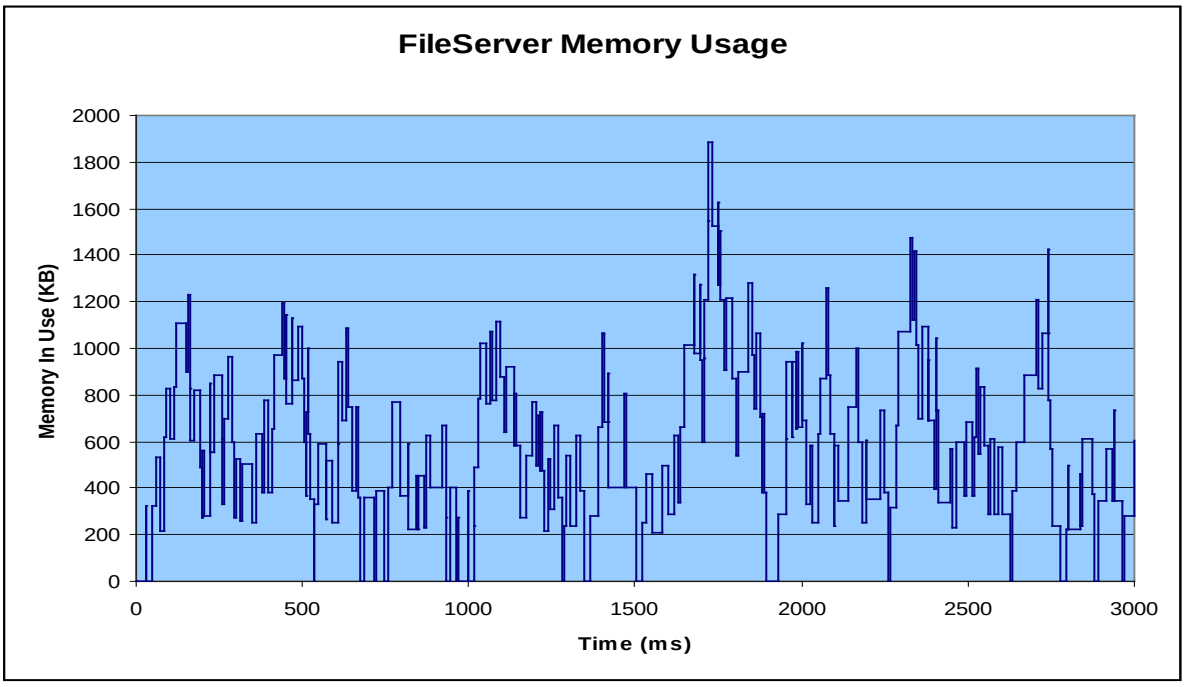
When you generate, compile, and run the simulation, you will see a new file created for each component and connector named “ElementName_ElementID_Reliability_Log.csv”. You can open this file in MS Excel. The first column is the time in milliseconds. The second column is the fraction of the total elapsed time that the component in not in a failure state. Plotting these values yields a graph like the one below:



3.5 Using the Memory Usage Extension (MicroxADL)

Once you have imported your model into the MicroxADL paradigm, fill in the `Memory usage` attribute for each `Task` with an equation that specifies the amount of memory in KB required to perform the task. You may use a constant value, a stochastic value, or some other equation that may include the size and/or value of an input or resource as a parameter.

When you generate, compile, and run the simulation, you will see a new file created for each component and connector named “ElementName_ElementID_Memory_Log.csv”. You can open this file in MS Excel. The first column is the time in milliseconds. The second column is the amount of memory being used by the component or connector. Plotting these values yields a graph like the one below:


FileServer Memory Usage
Memory In Use (KB)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
500
1000
1500
2000
2500
3000
Time (ms)

4 Troubleshooting

Using Visual Studio 2010

If you are using Microsoft Visual Studio 2010:

1. You may need to recompile the simulation generators.
2. You may need to recompile the adevs and newran libraries.

Registering the Simulation Generator

If you receive the error “Unable to register component. Maybe due to insufficient rights.”:

1. If you are running Windows Vista or Windows 7, make sure you are running GME under Administrator Mode and try disabling UAC.
2. Try recompiling the simulation generator.

If you receive the error “Unable to register component (0x********): The application has failed to start because its side-by-side configuration is incorrect. Please see the application event log or use the command-line sxstrace.exe tool for more detail.”:

1. Make sure you are running GME version 10.2.9.
2. Try compiling the simulation generator.